The Online Positioning User Service (OPUS): a Web Utility for Precise Geodetic Positioning

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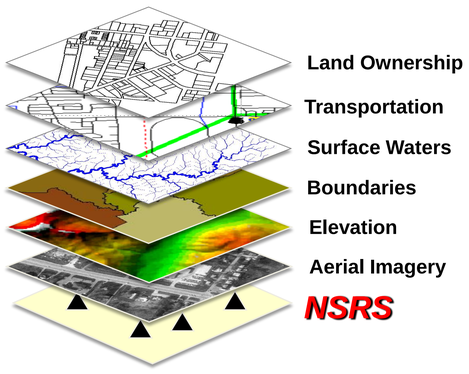


Figure 1. Typical geospatial data layers and NSRS, the foundation layer which provides a common spatial coordinate system and allows data from disparate sources to be attributed and analyzed within a consistent spatial framework.

NOAA's National Geodetic Survey defines and maintains the official United States spatial positioning infrastructure – the National Spatial Reference System (NSRS) (Fig. 1). The definitional foundation of today's NSRS is a nationwide network of Global Navigation Satellite System (GNSS) Continuously Operating Reference Stations (CORS) (Fig. 3). Originating in 1994 and today comprising some 2000 permanent, geodetic-quality GNSS receivers in various installation configurations, the CORS network involves more than 200 partnering organizations. Maintained with a high degree of coordinate consistency and reliability (Fig. 4), the CORS network is designed to support the broad spectrum of post-processed GNSS positioning techniques and applications employed in a wide range of geospatial disciplines.

With a goal of providing enhanced access to NSRS, and leveraging the utility of the CORS foundational framework, NGS in 2001 released the Online Positioning User Service (OPUS), a free, Web-based positioning utility with a simple user interface and minimal input requirements. OPUS performs CORS-referenced processing of user-submitted GNSS observation data, delivering via email the resultant positional coordinates and accuracy estimates, typically within minutes after the submission. Since 2014, an enhanced version of OPUS – OPUS-Projects – has provided heretofore unavailable access to free, Web-based geodetic network processing capability suited for highly demanding precise positioning applications.

CORS and OPUS together have evolved a modern nationwide positioning paradigm suited for myriad applications and requirements in today's research and operational geospatial realms (Fig. 2).

Figure 2. GNSS survey occupation for geophysical research and curious bison in Yellowstone National Park, Wyoming, USA. CORS and OPUS greatly simplify field logistics for precise positioning in geospatial projects.

CORS Network – the OPUS framework

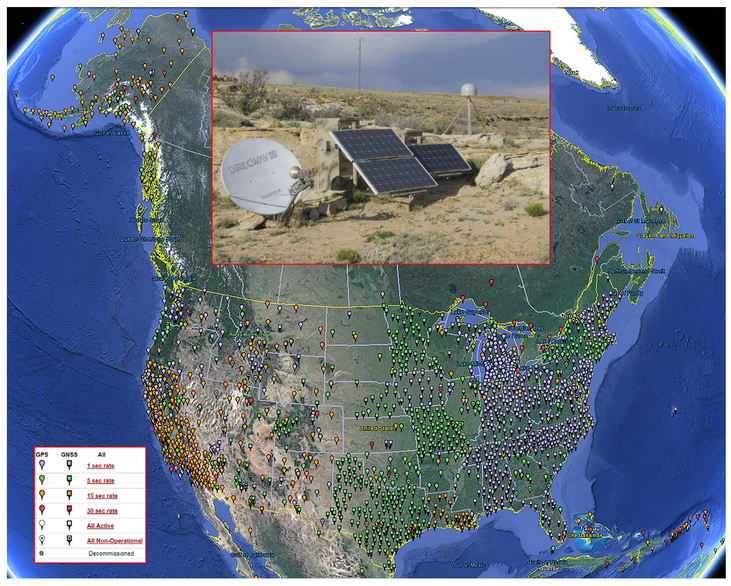


Figure 3. NGS CORS Network. Each of these 2000 sites features a permanently installed, geodetic-quality GNSS receiver (and peripheral hardware) which collects and transfers to NGS GNSS observation data for archiving, quality control, and public distribution. NGS provides published station coordinates and velocities in the North American Datum 1983 (NAD83) and the International GNSS Service 2008 (IGS08) reference frames; RINEX observation files; short- and long-term coordinate repeatability plots; and various site metadata. Typical monthly user demand is 3 to 4 million file downloads.

Inset photo of CORS site P028 (owned/operated by UNAVCO, www.unavco.org) at Chaco Culture National Historical Park, New Mexico, USA. P028 is self-contained, operating off-grid with solar panels, batteries, and satellite link for data transfer and remote monitoring. GNSS antenna/radome mounted atop drilled/braced monument is at right.

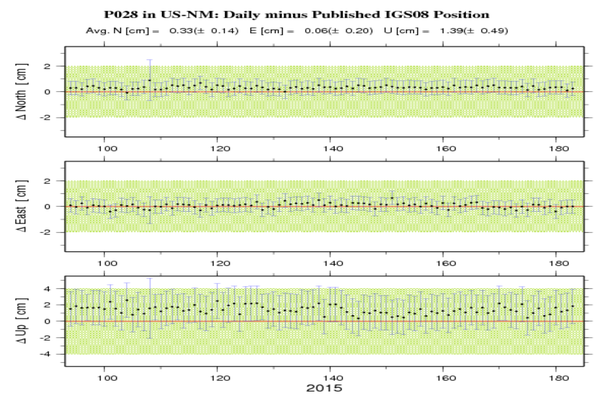


Figure 4. 90-day repeatability plots and summary statistics of CORS site P028 daily station coordinates (north, east, up) minus published IGS08 coordinates. Green shading indicates standard CORS positional tolerances; error bars are 1-sigma. Similar plots are generated daily for all CORS to monitor station and network consistency and reliability.

OPUS – fast, easy, consistent NSRS access

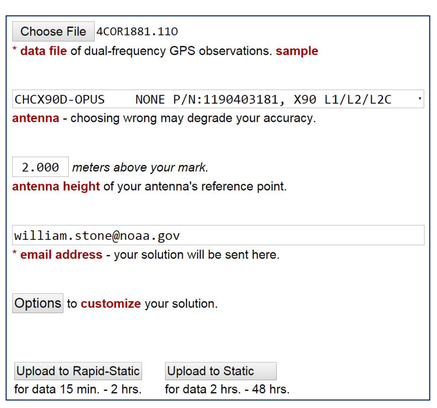


Figure 5. OPUS upload interface, illustrating minimal user input required for user submissions.

OPUS furthers the functionality and utility of the CORS network by providing a simple tool for accessing the precise coordinate framework of NSRS and computing user-mark coordinates derived from CORS data and published coordinates. OPUS comprises three processing variations: OPUS-Static(S) (2 to 48 hours of user data; single mark), OPUS-RapidStatic(RS) (15 minutes to 2 hours of user data; single mark), and OPUS-Projects (geodetic network solution of multiple marks and occupations). All OPUS versions require minimal user input through a simple Web interface (Fig. 5), with results delivered by email. Solution reports include coordinates and uncertainty estimates in both NAD83 and IGS08 reference frames, solution quality statistics, and Universal Transverse Mercator / State Plane Coordinate System coordinates and metadata. OPUS-S users submitting at least 4 hours of GNSS observation data have the option of sharing their results into a public database (Fig. 6). With recent typical monthly usage of 35 (up to 60) thousand submissions, OPUS is extremely popular with the geospatial community, helping evolve modern, robust access to NSRS.

OPUS-S/RS provide only single point solutions, and for applications requiring the enhanced geodetic rigor typically afforded by a network of inter-connected marks and least-squares adjustment, there is OPUS-Projects …

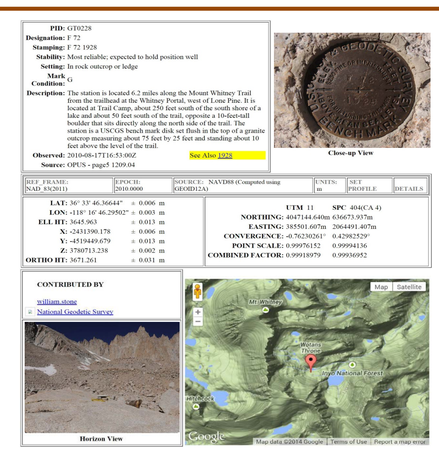


Figure 6. OPUS solution shared by the author to OPUS database.

OPUS-Projects – for geodetic networks

OPUS-Projects is a geodetic network processing and project management utility (Fig. 7) which empowers the user with considerable control over various project facets, including network design (Fig. 8), processing and adjustment constraint selection, and results output. Based on user-configurable preferences, OPUS-Projects can highlight for further investigation potential result shortcomings. The final result of an OPUS-Projects project is a set of mark coordinates (and uncertainties) derived from connections and constraints to the CORS and optionally to local passive geodetic control, potentially including vertical geodetic control (elevation data) for projects requiring accurate elevation results (Fig. 9). Project results include descriptive mark information and various statistical indicators of solution quality. Access to OPUS-Projects is restricted to registered users who have participated in an NGS OPUS-Projects workshop.

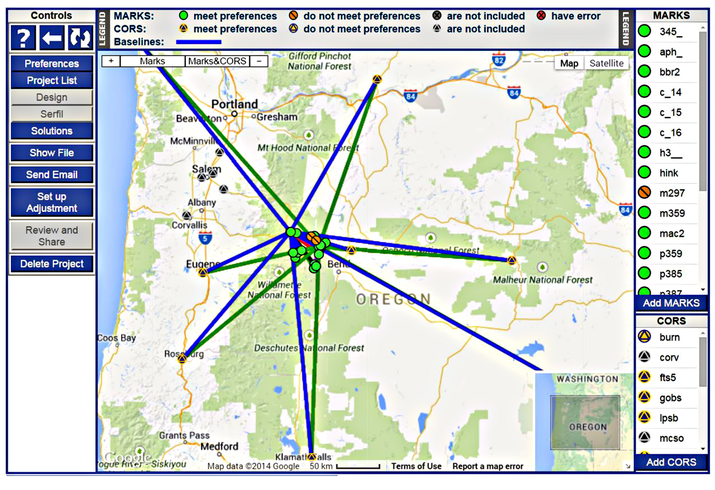
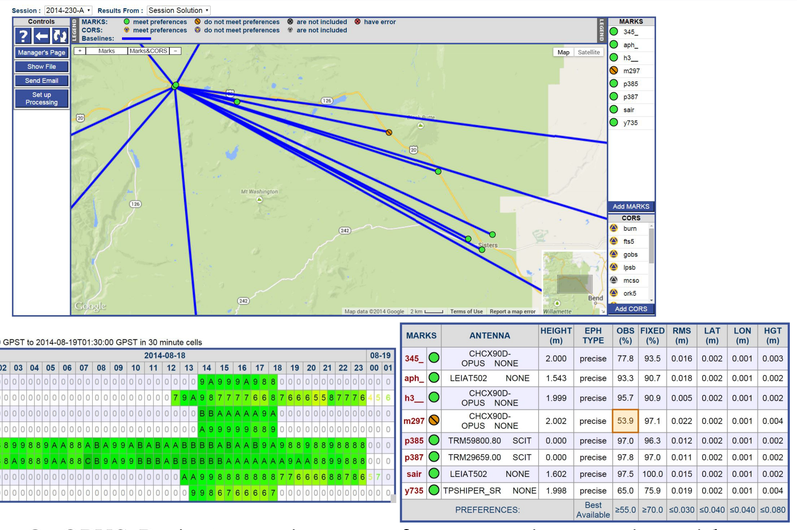


Figure 7. OPUS-Projects manager's page with project map, indicating project CORS and user marks, processed project baselines, and various software navigation controls.



MARKS	ANTENNA	HEIGHT (m)	EPH TYPE	OBS (%)	FIXED (%)	RMS (m)	LAT (m)	LON (m)	HGT (m)
345_	CHCX90D-OPUS NONE	2.000	precise	77.8	93.5	0.016	0.002	0.001	0.003
aph_	LEIAT502 NONE	1.543	precise	93.3	90.7	0.018	0.002	0.001	0.002
h3__	CHCX90D-OPUS NONE	1.999	precise	95.7	90.9	0.005	0.002	0.001	0.002
m297	CHCX90D-OPUS NONE	2.002	precise	53.9	97.1	0.022	0.002	0.001	0.004
p385	TRM59800.80 SCIT	0.000	precise	97.0	96.3	0.012	0.002	0.001	0.002
p387	TRM29659.00 SCIT	0.000	precise	97.8	97.0	0.011	0.002	0.001	0.002
sair	LEIAT502 NONE	1.602	precise	97.5	100.0	0.015	0.002	0.001	0.002
y735	TPSHIPER_SR NONE	1.998	precise	65.0	75.9	0.019	0.002	0.001	0.004
PREFERENCES:			Best Available	≥55.0	≥70.0	≤0.030	≤0.040	≤0.040	≤0.080

Figure 8. OPUS-Projects session page for one project session with map of session baselines and satellite data availability and solution quality indicator tables (orange shading highlights out-of-preference value).

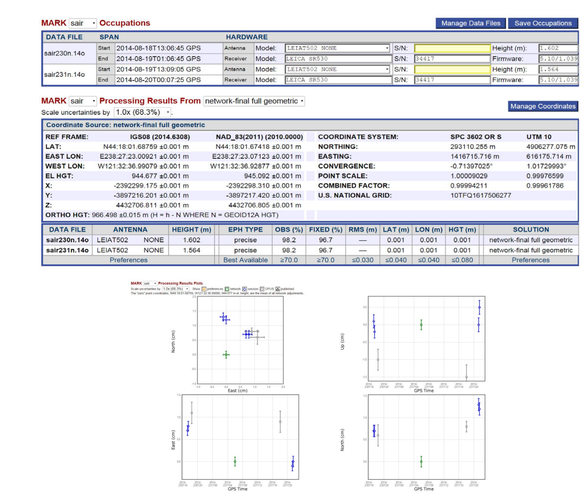


Figure 9. OPUS-Projects processing results table and plots for one mark, allowing comparison of OPUS, session, and network results.

For more information about the National Geodetic Survey, CORS and OPUS, visit: geodesy.noaa.gov or contact the author at william.stone@noaa.gov

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